OSTEOLOGY AND ORBITAL CONTENTS

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CHAPTER CONTENTS

INTRODUCTION

A crucial knowledge of the anatomical structures that form the eye and orbit is important for developing a firm foundation for understanding how disease affects the eye. This chapter will provide an overview of the general principles governing ocular anatomy, and will then describe the structure of each component of the eye and orbit and the significance this has for the understanding of how the eye functions.

Anatomical terminology

In order to understand the structure and function of regions of the eye, it is first important to be familiar with universal terms that allow optometrists to describe the position and relations of each structure. These terms are often derived from latin terms and it can be helpful to remember them by their latin origin.

The head is divided into three imaginary planes (see Figure 1.1).

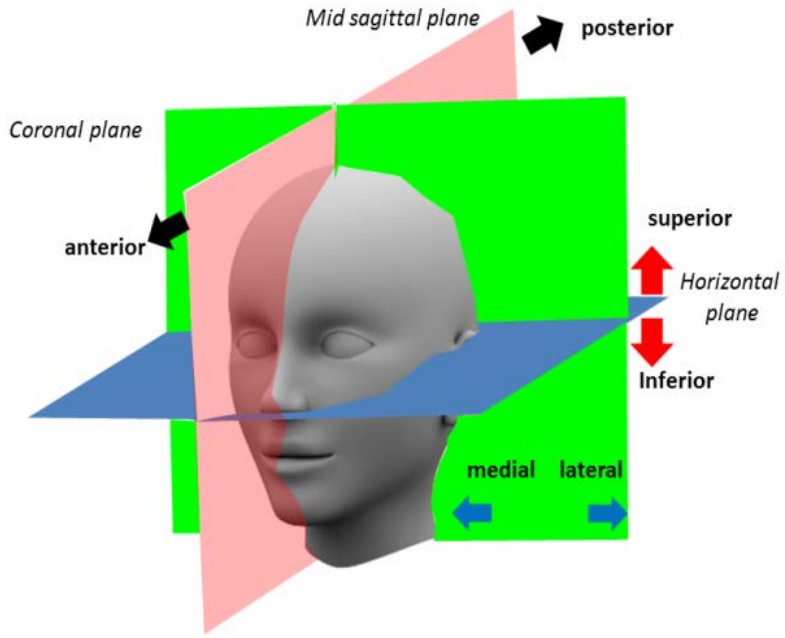

Figure 1.1: *Diagram showing the head segregated by the three planes (mid-sagittal, coronal and horizontal).*

The first plane, called the **mid-sagittal plane**, divides the head into a right and left half. Sagittal comes from the latin term *sagitta* meaning "arrow". Imagining the head being pierced by an arrow from front to back may help to remember the definition of the mid-sagittal plane. In figure 1.1, this plane is shown in pink.

The second plane, called the **horizontal plane,** runs at right angles to the mid-sagittal plane and separates the head into a top and a bottom half.

The third plane, called the **coronal plane,** divides the head into a front half and back half. The term coronal comes from the latin word *corona*, meaning "garland" or crown. To remember this term, it can be helpful to think of what you see when you look at a kind wearing a crown. The view of the king's head with the crown is analogous to the coronal plane. This plane runs at right angles to both the mid-sagittal and horizontal plane.

To describe the relative position of anatomical structures, one uses the terms

- **Medial or lateral** to refer to the location nearer or further from the mid-sagittal plane. In optometry, **nasal** or **temporal** are also often used
- **Anterior or posterior** to refer to the location of the structure at the front or back of the head
- **Superior or inferior** to refer to the location being towards the top or bottom of the head.

Some structures are may also be referred to as **dorsal or ventral** referring to their location relative to the back (latin; dorsum; back) or stomach (latin *venter;* belly). Terms such as **rostral** (latin, rostrum; beak) and **caudal** (latin, cauda; tail) are also often used when describing neural structures of the head. Finally, within the tissues of the eye, the location of structures may be referred to as **superficial** or **deep**, referring to their location relative to the surface of the body.

BONES OF THE SKULL AND ORBIT

The skull consists of 22 bones that are divided into those that form the cranium and those that form the face (Figure 1.2). Only those bones that are of significance to understanding the bones that form the orbit or that have significance in understanding the visual pathway are described here. Not all 22 bones are described below.

The bones that form the cranium include the occipital bone, most posteriorly, two parietal bones on the lateral sides of the head, two temporal bones and the frontal bone forming the forehead (see figure 1.2). The bones that form the face include the zygomatic bones located laterally, the maxilla forming the upper jaw, and mandible forming the lower jaw. There are a number of other bones that form the face of the skull, however, these are not listed here because they have little relevance to the eye.

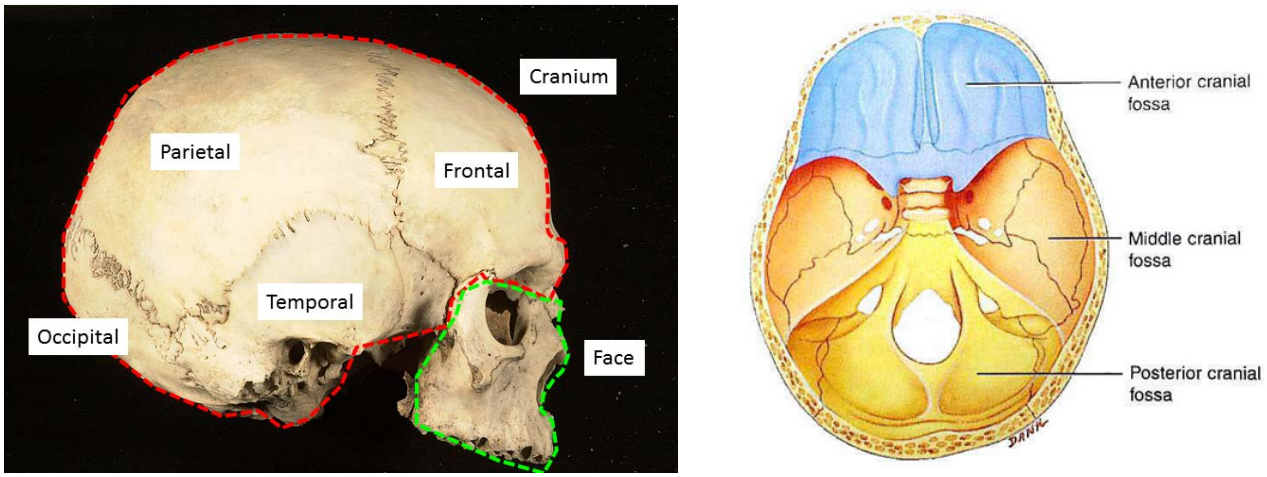

Figure 1.2 *(A) The bones of the skull. (B) The three cranial fossae*

The inside of the skull comprises the three cranial fossae called the anterior cranial fossa, middle cranial fossa and posterior cranial fossa. These three cranial fossae house the various lobes of the brain and can be considered like a staircase proceeding from the anterior cranial fossa down to the posterior cranial fossa. The anterior cranial fossa is formed by the orbital plates of the frontal bone. In addition, the ethmoid bone is located in the middle of the anterior cranial fossa, and can be easily seen by the many small holes that form the cribiform plate of the ethmoid. This is the region where the nerves from the upper nasal cavity pass through the skull.

The middle cranial fossa is formed by the sphenoid bone anteriorly, together with the temporal bone. The sphenoid bone is an important bone that sits within the middle of the middle cranial fossa.

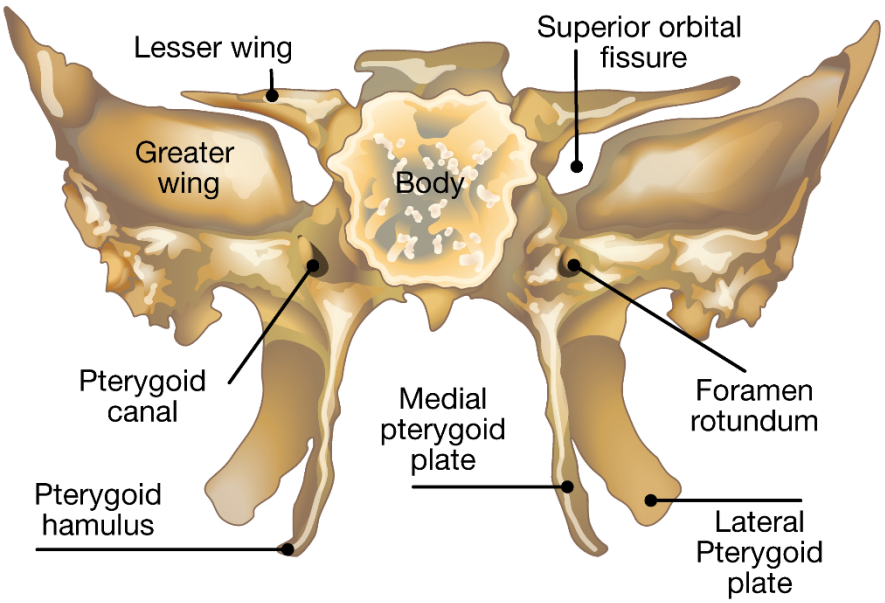

Figure 1.3 *The sphenoid bone viewed from the front. {image inspired by: http://medical-dictionary.thefreedictionary.com/_/viewer.aspx?path=MosbyMD&name=sphenoid_bone.jpg}*

As shown in Figure 1.3, when the sphenoid bone is examined in isolation of the other bones of the skull, it looks a bit like an insect with two wings: the upper wing is called the lesser wing of sphenoid, whilst the lower much larger wing is called the greater wing of sphenoid. The gap between the two wings forms a very important fissure located at the apex of the orbit, called the superior orbital fissure. The main body of the sphenoid bone is called the body of sphenoid. The body of sphenoid looks a bit like a horse saddle, and for this reason is called the sella turcica, or "Turkish saddle". The sella turcica is the place where the pituitary gland sits.

The posterior cranial fossa is formed by the occipital bone.

The eye ball sits within the bony orbit of the skull. Each of the two orbits is shaped roughly as a square pyramid, comprising an apex, base and four walls. The base of the orbit is formed by two margins: the supraorbital margin is formed by a thick ridge of the frontal bone, and the infraorbital margin isformed laterally by the zygomatic bone and medially by part of the maxilla. These bones are shown in Figure 1.4.

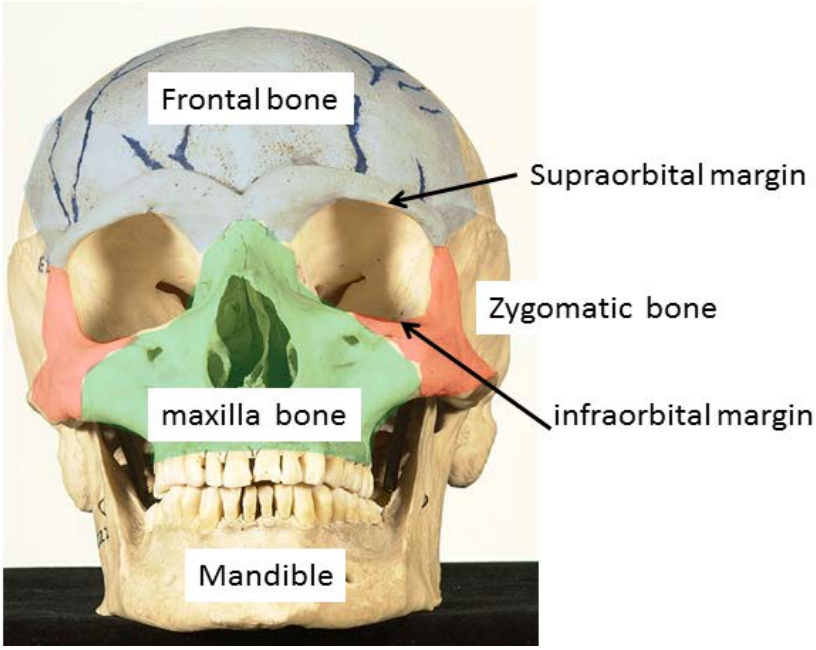

Figure 1.4: *The bones of the skull form the margins of the orbit. The frontal bone is shown in blue shading, the zygomatic bone by orange shading and the maxilla in green.*

The bones that form the four walls of the orbit are as follows:

- ***Roof of the orbit:*** orbital plate of the frontal bone, lesser wing of sphenoid
- ***Floor of the orbit***: orbital plate of the maxilla, zygomatic and palatine bone
- ***Lateral wall:*** zygomatic, greater wing of sphenoid.
- ***Medial wall:*** maxilla, lacrimal, ethmoid, and body of sphenoid

In addition to the bones of the orbit, there are a series of foraminae that communicate vital nerves and blood vessels into the orbit. The **superior orbital fissure** is formed by the gap between the lesser wing and greater wing of sphenoid. It is the major entry point for the majority of cranial nerves entering the orbit, with the exception of the optic nerve. The optic canal is located within the body of the sphenoid bone. It is a small circular foramen that allows for the passage of the optic nerve and central retinal artery and vein into the orbit. The **inferior orbital fissure** is located between the lateral wall and floor of the orbit. It provides communication between the orbit and the inferotemporal fossa and pterygopalatine fossa. The major nerves that pass through the inferior orbital fissure include the zygomatic and infraorbital nerves as well as the branches from the pterygopalatine ganglion.

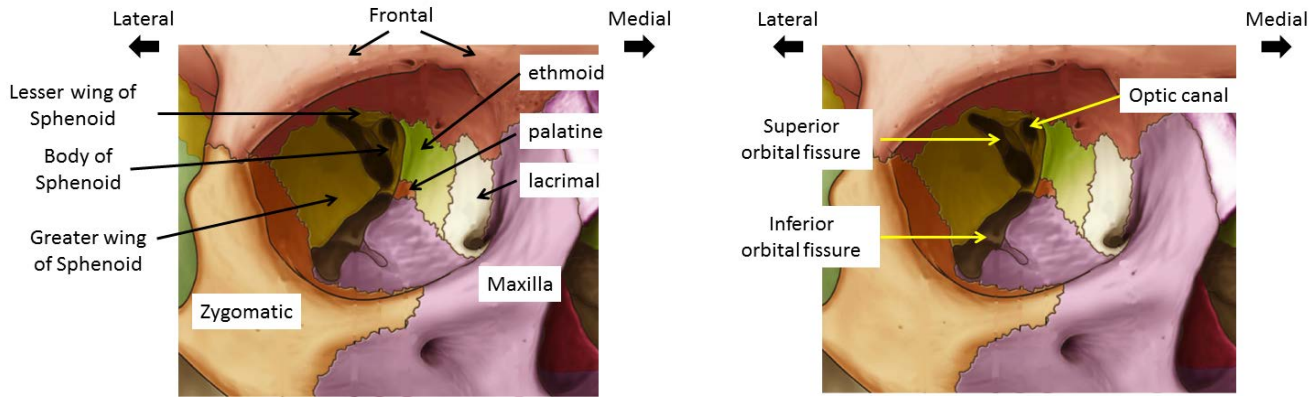

***Figure 1.5**: Schematic diagram of the right orbit showing (A) the bones of the orbit and (B) and three major foraminae.*

THE PARANASAL SINUSES

A sinus is a cavity. With respect to bone, there are several paranasal sinuses, or cavities within the bones that form the skull. The paranasal sinuses include the maxillary sinus, frontal sinus, ethmoid sinus, and sphenoid sinus. Each sinus is an air-filled cavity that provides communication with the nasal cavity. They are lined by mucous membranes that secrete mucous secretions that move towards the nasal cavity via the actions of cilia that are located on the epithelial surface of the mucous membranes. In figure 1.6, the exit routes of several of the paranasal sinuses are indicated by the arrows. Infection can spread from the nasal cavity to the sinuses. The main functions of the paranasal sinuses are to warm and moisten the air, lighten the skull and add resonance to the voice.

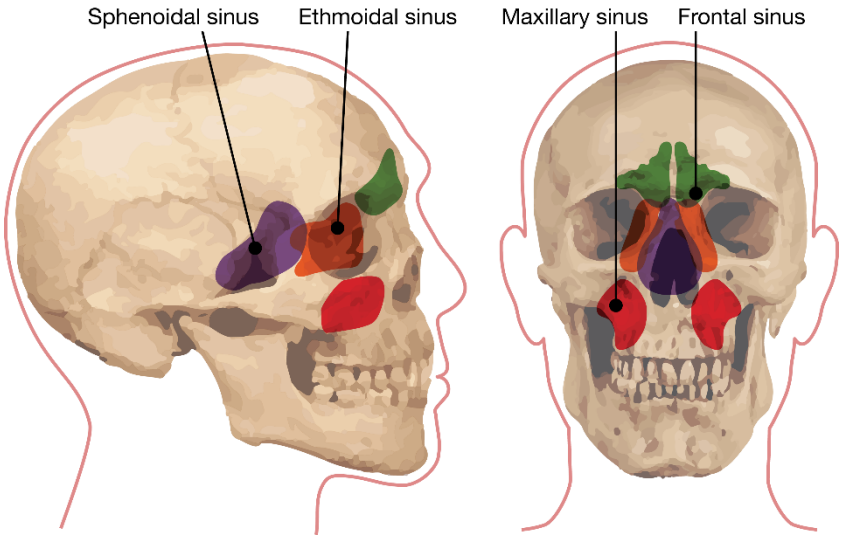

Figure 1.6: *(A) schematic showing the location of the paranasal sinuses (image inspired by http://www.thirdage.com/hc/c/what-is-sinusitis)*

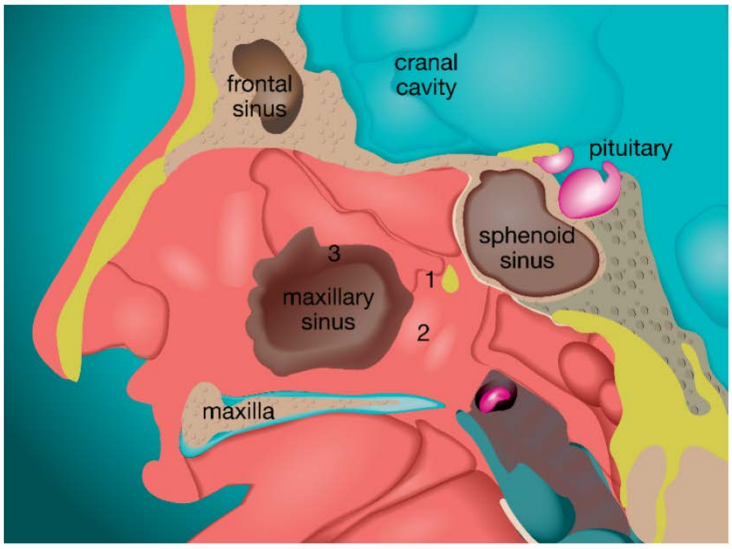

Figure 1.6: *(B) The paranasal sinuse indicated in a bones of the skull. (Image inspired by http://home.comcast.net/~wnor/lesson9.htm)*

ORBITAL CONTENTS

Covering the bone and filling the space between the bone and the globe are a series of connective tissue layers, together with orbital fat (Figure 1.7 and 1.8). Although the connective tissue within the orbit is continuous, it is helpful to understand each layer and how these layers are arranged. Below each are described, from the first covering of the bone.

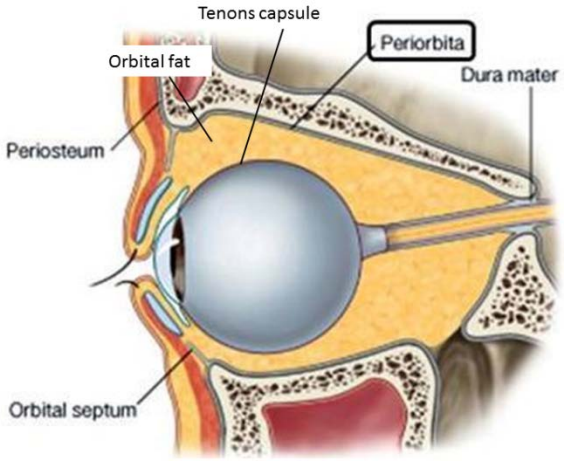

Figure 1.7*: Schematic diagram showing the location of the periorbita, tenons capsule, orbital septum and orbital fat.*

The **periorbita or orbital fascia** covers the bone of the orbit. It is composed of a dense connective tissue and serves as an attachment site for the extraocular muscles, as well as a support structure for the blood supply to the orbital bones. The periorbita is only loosely attached to the bone, with the exception of the orbital margin, sutures, fissures and foramina.

The orbital septum: At the orbital margins, the periorbita is continuous with a connective tissue sheet called the orbital septum (also termed the palpebral fascia). This sheet is circular, running around the entire rim of the orbit to the tarsal plate within the eyelids (Figure 1.7). This is a strong barrier that helps prevent infection from entering the orbit.

Tenon's Capsule (or the Fascial Sheath) is a sheet of dense connective tissue that covers the globe (Figure 1.7). It lies between the conjunctiva and episclera and merges with these layers at the limbus. Posteriorly, it merges with the dural sheath of the optic nerve. It is pierced in places by the optic nerve, vortex veins and ciliary nerves as well as the extraocular muscles. Thickenings of Tenon's capsule are attached to the orbital wall medially and laterally form the *check ligaments* which limit the actions of the medial and lateral *rectus muscles*. The capsule is thickest inferiorly, increasing the support of the eyeball by forming the 'hammock-like' suspensory ligament of Lockwood.

Orbital fat: The spaces not occupied by ocular structures, connective tissue or nerves are filled with adipose tissue (Figure 1.8). There are generally four adipose tissue compartments located within the muscle cone surrounding the optic nerve. In addition, there is a ring of adipose tissue that separates the extraocular muscles from the wall of the orbit.

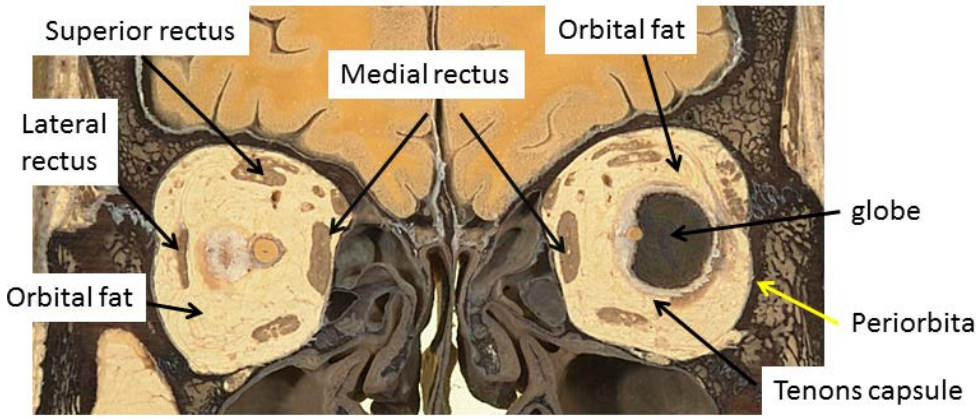

***Figure 1.8**: Coronal section through the head at the level of the posterior globe/optic nerve. Orbital fat, and extraocular muscles are visible.*

REFERENCES AND FURTHER READING

For alternative or more detailed descriptions of different visual structures, the student may find the following books helpful.

- ***Adler's Physiology of the Eye*. 11th Levin. Nilsspm. Ver Hoeve, Wu, Kaufman, AlmSaunders 2011.**
- ***Clinical Anatomy of the Visual System*.2nd ed Remington, Elsevier 2005.**
- ***Clinical Anatomy of the Eye*. Snell and Lemp, Blackwell 1998.**
- ***The Eye Basic Sciences in Practice. Forrester, 2nd ed Dick, McMenamin, Lee, 2003***